

Modern Lens Design
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Chapter

22

Scanner/ f - θ and Laser Disk/Collimator Lenses

22.1 Monochromatic Systems

In a system which is truly monochromatic, the designer is no longer constrained by the need to achromatize the lens system. Thus high-index flint glasses can be used in positive elements and low-index crown glasses can be used in negative elements. This is obviously beneficial as regards the Petzval curvature, and obviates any need to use the expensive lanthanum glasses for the high-index elements. The resulting lens is, of course, a hyperchromat and is suitable only for use with very monochromatic light sources.

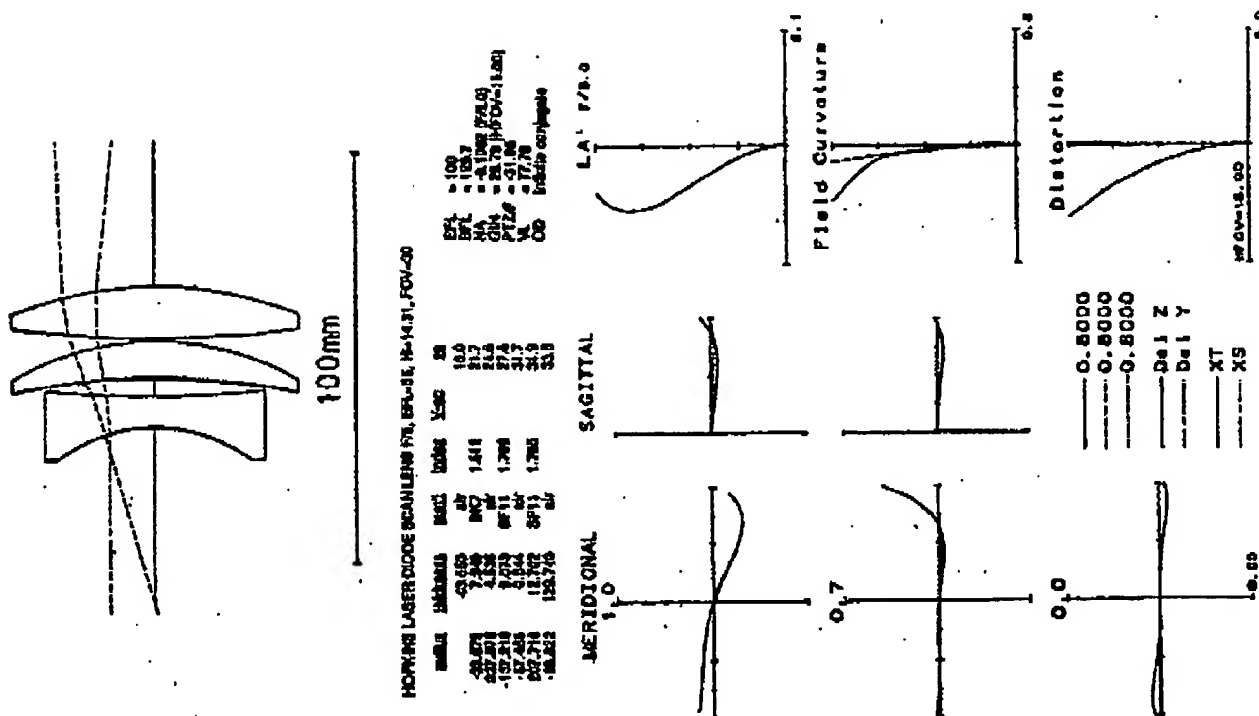
22.2 Scanner Lenses

The scanner lens operates with an oscillating mirror which scans the image across the field. To minimise the size of the scanning mirror, the pupil of the system is located at the mirror. An ordinary distortion-free lens has an image height (distance from the axis) which follows the rule $h = f \tan \theta$. When the image is scanned across the field by a mirror with a constant angular velocity, its linear velocity changes; the exposure produced will vary with the velocity. In order to achieve a uniform exposure across the field, distortion is deliberately introduced so that the image position relationship becomes $h = f\theta$. Note that all of the designs in this section have a negative distortion of this type.

The simplest scanner lens is a single meniscus lens, similar to the meniscus landscape lens. A two-element lens with the negative ele-

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is a simple three-element lens, in a - + + configuration, with the negative element made of low-index BK7 glass (517.643) and the positive elements made of SF11, an inexpensive, stable, high-index flint. This basic configuration (- + +) is not only nearly ubiquitous, but quite versatile; it has even been used for long-wavelength (10.6- μ m) scanners (with suitable materials). A slower, wider-angle scanner lens is shown in Fig. 22.2; here all three elements have the same index, and this order is + - +. Figure 22.3 achieves a higher speed and wider angle by splitting the last element (and shifting some power from the front element). Figure 22.4 is a similar configuration, except that the negative element is low-index BK7. The last of these examples is Fig. 22.5, with a fifth element added on the image side.

The last two scanner lenses, Figs. 22.6 and 22.7, are examples of telecentric systems in which the exit pupil is located at infinity, so that the principal ray of the imaging cone is always normal to the focal plane as the image is scanned across the field. As can be seen, telecentricity not only tends to require a complex design, but also requires that the lens aperture be larger than the image field.

Note that Fig. 20.6 shows a scanner lens with zooming capability.

22.3 Laser Disk, Focusing, and Collimator Lenses

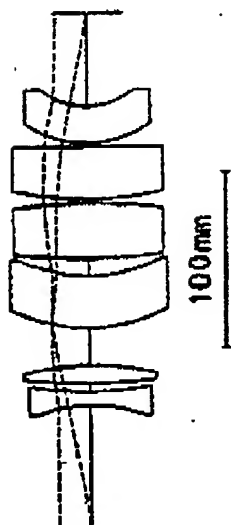
Figure 22.8 shows a typical molded glass laser disk lens. Both surfaces are convex with general spheric deformations. The lens thickness is important to the design in that it allows for some correction of the astigmatism. At the speed of f/0.9 of this example, it is of course vital that the plastic cladding on the disk be included in the design. The actual focal length of this type of lens is to the order of 6 mm, at which focal length the design wavefront aberration is a tiny fraction of a wavelength. This type of lens is often molded in plastic as well as glass.

Figure 22.9 is an airspaced doublet, whose correction is based on the same principles as outlined in Chap. 6 except that, as a monochromatic system, both elements can be made from a high-index flint glass (SF8 805-254). Note that if the configuration is chosen so that the spherical aberration is well-corrected, then the lens can be used for several different wavelengths, although it will require refocusing for each wavelength.

Figures 22.10, 22.11, and 22.12 are examples of spherical-surfaced laser disk lenses. Note that, in each case, the final positive element is spaced well away from the aperture stop in order to allow for a modest correction of the astigmatism. In Fig. 22.12 the designer has com-

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HOPKINS ME-33 LASER SCAN LENS; FFLA EFL=42, FORMAT IS FOM-19

Surf	Radius	Surf	Surf	Surf	Surf
1	57.400	6	57.400	11	57.400
2	70.047	7	57.400	12	57.400
3	13.254	8	57.400	13	57.400
4	13.254	9	57.400	14	57.400
5	13.254	10	57.400	15	57.400
6	13.254	11	57.400	16	57.400
7	13.254	12	57.400	17	57.400
8	13.254	13	57.400	18	57.400
9	13.254	14	57.400	19	57.400
10	13.254	15	57.400	20	57.400
11	13.254	16	57.400	21	57.400
12	13.254	17	57.400	22	57.400
13	13.254	18	57.400	23	57.400
14	13.254	19	57.400	24	57.400
15	13.254	20	57.400	25	57.400
16	13.254	21	57.400	26	57.400
17	13.254	22	57.400	27	57.400
18	13.254	23	57.400	28	57.400
19	13.254	24	57.400	29	57.400
20	13.254	25	57.400	30	57.400
21	13.254	26	57.400	31	57.400
22	13.254	27	57.400	32	57.400
23	13.254	28	57.400	33	57.400
24	13.254	29	57.400	34	57.400
25	13.254	30	57.400	35	57.400
26	13.254	31	57.400	36	57.400
27	13.254	32	57.400	37	57.400
28	13.254	33	57.400	38	57.400
29	13.254	34	57.400	39	57.400
30	13.254	35	57.400	40	57.400
31	13.254	36	57.400	41	57.400
32	13.254	37	57.400	42	57.400
33	13.254	38	57.400	43	57.400
34	13.254	39	57.400	44	57.400
35	13.254	40	57.400	45	57.400
36	13.254	41	57.400	46	57.400
37	13.254	42	57.400	47	57.400
38	13.254	43	57.400	48	57.400
39	13.254	44	57.400	49	57.400
40	13.254	45	57.400	50	57.400
41	13.254	46	57.400	51	57.400
42	13.254	47	57.400	52	57.400
43	13.254	48	57.400	53	57.400
44	13.254	49	57.400	54	57.400
45	13.254	50	57.400	55	57.400
46	13.254	51	57.400	56	57.400
47	13.254	52	57.400	57	57.400
48	13.254	53	57.400	58	57.400
49	13.254	54	57.400	59	57.400
50	13.254	55	57.400	60	57.400
51	13.254	56	57.400	61	57.400
52	13.254	57	57.400	62	57.400
53	13.254	58	57.400	63	57.400
54	13.254	59	57.400	64	57.400
55	13.254	60	57.400	65	57.400
56	13.254	61	57.400	66	57.400
57	13.254	62	57.400	67	57.400
58	13.254	63	57.400	68	57.400
59	13.254	64	57.400	69	57.400
60	13.254	65	57.400	70	57.400
61	13.254	66	57.400	71	57.400
62	13.254	67	57.400	72	57.400
63	13.254	68	57.400	73	57.400
64	13.254	69	57.400	74	57.400
65	13.254	70	57.400	75	57.400
66	13.254	71	57.400	76	57.400
67	13.254	72	57.400	77	57.400
68	13.254	73	57.400	78	57.400
69	13.254	74	57.400	79	57.400
70	13.254	75	57.400	80	57.400
71	13.254	76	57.400	81	57.400
72	13.254	77	57.400	82	57.400
73	13.254	78	57.400	83	57.400
74	13.254	79	57.400	84	57.400
75	13.254	80	57.400	85	57.400
76	13.254	81	57.400	86	57.400
77	13.254	82	57.400	87	57.400
78	13.254	83	57.400	88	57.400
79	13.254	84	57.400	89	57.400
80	13.254	85	57.400	90	57.400
81	13.254	86	57.400	91	57.400
82	13.254	87	57.400	92	57.400
83	13.254	88	57.400	93	57.400
84	13.254	89	57.400	94	57.400
85	13.254	90	57.400	95	57.400
86	13.254	91	57.400	96	57.400
87	13.254	92	57.400	97	57.400
88	13.254	93	57.400	98	57.400
89	13.254	94	57.400	99	57.400
90	13.254	95	57.400	100	57.400
91	13.254	96	57.400	101	57.400
92	13.254	97	57.400	102	57.400
93	13.254	98	57.400	103	57.400
94	13.254	99	57.400	104	57.400
95	13.254	100	57.400	105	57.400
96	13.254	101	57.400	106	57.400
97	13.254	102	57.400	107	57.400
98	13.254	103	57.400	108	57.400
99	13.254	104	57.400	109	57.400
100	13.254	105	57.400	110	57.400
101	13.254	106	57.400	111	57.400
102	13.254	107	57.400	112	57.400
103	13.254	108	57.400	113	57.400
104	13.254	109	57.400	114	57.400
105	13.254	110	57.400	115	57.400
106	13.254	111	57.400	116	57.400
107	13.254	112	57.400	117	57.400
108	13.254	113	57.400	118	57.400
109	13.254	114	57.400	119	57.400
110	13.254	115	57.400	120	57.400
111	13.254	116	57.400	121	57.400
112	13.254	117	57.400	122	57.400
113	13.254	118	57.400	123	57.400
114	13.254	119	57.400	124	57.400
115	13.254	120	57.400	125	57.400
116	13.254	121	57.400	126	57.400
117	13.254	122	57.400	127	57.400
118	13.254	123	57.400	128	57.400
119	13.254	124	57.400	129	57.400
120	13.254	125	57.400	130	57.400
121	13.254	126	57.400	131	57.400
122	13.254	127	57.400	132	57.400
123	13.254	128	57.400	133	57.400
124	13.254	129	57.400	134	57.400
125	13.254	130	57.400	135	57.400
126	13.254	131	57.400	136	57.400
127	13.254	132	57.400	137	57.400
128	13.254	133	57.400	138	57.400
129	13.254	134	57.400	139	57.400
130	13.254	135	57.400	140	57.400
131	13.254	136	57.400	141	57.400
132	13.254	137	57.400	142	57.400
133	13.254	138	57.400	143	57.400
134	13.254	139	57.400	144	57.400
135	13.254	140	57.400	145	57.400
136	13.254	141	57.400	146	57.400
137	13.254	142	57.400	147	57.400
138	13.254	143	57.400	148	57.400
139	13.254	144	57.400	149	57.400
140	13.254	145	57.400	150	57.400
141	13.254	146	57.400	151	57.400
142	13.254	147	57.400	152	57.400
143	13.254	148	57.400	153	57.400
144	13.254	149	57.400	154	57.400
145	13.254	150	57.400	155	57.400
146	13.254	151	57.400	156	57.400
147	13.254	152	57.400	157	57.400
148	13.254	153	57.400	158	57.400
149	13.254	154	57.400	159	57.400
150	13.254	155	57.400	160	57.400
151	13.254	156	57.400	161	57.400
152	13.254	157	57.400	162	57.400
153	13.254	158	57.400	163	57.400
154	13.254	159	57.400	164	57.400
155	13.254	160	57.400	165	57.400
156	13.254	161	57.400	166	57.400
157	13.254	162	57.400	167	57.400
158	13.254	163	57.400	168	57.400
159	13.254	164	57.400	169	57.400
160	13.254	165	57.400	170	57.400
161	13.254	166	57.400	171	57.400
162	13.254	167	57.400	172	57.400
163	13.254	168	57.400	173	57.400
164	13.254	169	57.400	174	57.400
165	13.254	170	57.400	175	57.400
166	13.254	171	57.400	176	57.400
167	13.254	172	57.400	177	57.400
168	13.254	173	57.400	178	57.400
169	13.254	174	57.400	179	57.400
170	13.254	175	57.400	180	57.400
171	13.254	176	57.400	181	57.400
172	13.254	177	57.400	182	57.400
173	13.254	178	57.400	183	57.400
174	13.254	179	57.400	184	57.400
175	13.254	180	57.400	185	57.400
176	13.254	181	57.400	186	57.400
177	13.254	182	57.400	187	57.400
178	13.254	183	57.400	188	57.400
179	13.254	184	57.400	189	57.400
180	13.254	185	57.400	190	57.400
181	13.254	186	57.400	191	57.400
182	13.254	187	57.400	192	57.400
183	13.254	188	57.400	193	57.400
184	13.254	189	57.400	194	57.400
185	13.254	190	57.400	195	57.400
186	13.254	191	57.400	196	57.400
187	13.254	192	57.400	197	57.400
188	13.254	193	57.400	198	57.400
189	13.254	194	57.400	199	57.400
190	13.254	195	57.400	200	57.400
191	13.254	196	57.400	201	57.400
192	13.254	197	57.400	202	57.400
193	13.254	198	57.400	203	57.400
194	13.254	199	57.400	204	57.400
195	13.254	200	57.400	205	57.4